AK-2-25, AK-2A-25, & AK-3A-25 LV-VSR
Breaker-To-Motor Starter Conversion

DISCLAIMER OF WARRANTIES AND LIMITATION OF LIABILITY

The information, recommendations, descriptions and safety notations in this document are based on Eaton’s experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in appropriate Eaton selling policies or other contractual agreement between Eaton and the purchaser.

THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES.

In no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability or otherwise for any special, indirect, incidental or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations and descriptions contained herein. The information contained in this manual is subject to change without notice.

⚠️ WARNING ⚠️

IMPROPERLY INSTALLING OR MAINTAINING THESE PRODUCTS CAN RESULT IN DEATH, SERIOUS PERSONAL INJURY, OR PROPERTY DAMAGE

READ AND UNDERSTAND THESE INSTRUCTIONS BEFORE ATTEMPTING ANY UNPACKING, ASSEMBLY, OPERATION, OR MAINTENANCE OF THE VACUUM STARTER REPLACEMENT.

INSTALLATION OR MAINTENANCE SHOULD BE ATTEMPTED ONLY BY QUALIFIED PERSONNEL. THIS INSTRUCTION BOOK SHOULD NOT BE CONSIDERED ALL INCLUSIVE REGARDING INSTALLATION OR MAINTENANCE PROCEDURES. IF FURTHER INFORMATION IS REQUIRED, YOU SHOULD CONSULT EATON’S ELECTRICAL SERVICES & SYSTEMS.

THE VACUUM STARTER REPLACEMENTS DESCRIBED IN THIS BOOK ARE DESIGNED AND TESTED TO OPERATE WITHIN THEIR NAMEPLATE RATINGS. OPERATION OUTSIDE OF THESE RATINGS MAY CAUSE THE EQUIPMENT TO FAIL, RESULTING IN DEATH, BODILY INJURY, AND PROPERTY DAMAGE.

ALL APPLICABLE SAFETY CODES, SAFETY STANDARDS AND/OR REGULATIONS RELATED TO THIS TYPE OF EQUIPMENT MUST BE STRICTLY FOLLOWED.

THESE VACUUM STARTER REPLACEMENTS ARE DESIGNED TO BE INSTALLED PURSUANT TO THE AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) AND THE NATIONAL ELECTRICAL CODE (NEC). SERIOUS INJURY, INCLUDING DEATH, CAN RESULT FROM FAILURE TO FOLLOW THE PROCEDURES OUTLINED IN THIS MANUAL.

These products were manufactured by Eaton Corporation at the Power Breaker Center: 310 Maxwell Avenue, Greenwood, SC 29646. All possible contingencies that may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation, or maintenance of particular equipment, contact a local Eaton representative.
## Table of Contents

**SECTION 1: INTRODUCTION**
- 1.1 AVAILABLE MOTOR STARTER REPLACEMENTS 4

**SECTION 2: SAFE PRACTICES**

**SECTION 3: RECEIVING, HANDLING, AND STORAGE**
- 3.1 RECEIVING 8
- 3.2 HANDLING 8
- 3.3 STORAGE 8
- 3.4 LV-VSR APPROXIMATE WEIGHTS 8

**SECTION 4: DESCRIPTION AND OPERATION**
- 4.1 ELECTRICAL CONTROL 13
- 4.2 BUSHING & DISCONNECTING CONTACT ASSEMBLIES 13
- 4.3 SECONDARY CONNECTION BLOCK 14
- 4.4 INTERLOCKS 14

**SECTION 5: INSPECTION**
- 5.1 EXAMINATION FOR DAMAGE 15
- 5.2 ELECTRONIC OVERLOAD RELAY C440 16
- 5.3 MANUAL OPERATIONAL CHECK 18
- 5.4 ELECTRICAL OPERATIONAL CHECKS 18

**SECTION 5.A: INSTALLATION OF AK-2-25 LV-VSR**
- 5.A.1 CELL MODIFICATION INSTRUCTIONS 19
- 5.A.2 COMPARTMENT DOOR MODIFICATIONS 19
- 5.A.3 INSERTION PROCEDURE 20
- 5.A.4 REMOVAL PROCEDURE 21

**SECTION 5.B: INSTALLATION OF AK-2A-25 LV-VSR**
- 5.B.1 CELL MODIFICATION INSTRUCTIONS 22
- 5.B.2 INSERTION PROCEDURE 22
- 5.B.3 REMOVAL PROCEDURE 23

**SECTION 6: INSPECTION AND MAINTENANCE**
- 6.1 INTRODUCTION 24
- 6.2 FREQUENCY OF INSPECTION 24
- 6.3 INSPECTION & MAINTENANCE PROCEDURES 24
- 6.4 VACUUM INTERRUPTER INTEGRITY TEST 25
- 6.5 INSULATION 25
- 6.6 INSULATION INTEGRITY CHECK 25
- 6.7 MECHANISM CHECK 26
- 6.8 LUBRICATION 26
- 6.9 PRIMARY CIRCUIT RESISTANCE CHECK 26
- 6.10 MAGNET OPERATING RANGE 26

**SECTION 7: REPLACEMENT OF COMPONENTS**
- 7.1 GENERAL 28
- 7.1.1 ORDERING INSTRUCTIONS 28
SECTION 1: INTRODUCTION

The purpose of this instruction book is to provide instructions for receiving, handling, storage, installation, operation and maintenance of Type LV-VSR, Low Voltage - Vacuum Starter Replacement Units. These units are horizontal draw-out type removable Vacuum Starter Replacements for existing LV Metal-Enclosed Switchgear with breakers of the same type and rating. LV-VSRs provide reliable control, protection and performance, with ease of handling and maintenance.

This book is intended to be used in conjunction with the technical information provided with the original equipment order which includes but is not limited to electrical control schematics and wiring diagrams, installation plans, and procedures for installation and maintenance of accessory items.

Satisfactory performance is dependant upon proper application correct installation, and adequate maintenance. It is strongly recommended that this instruction book be carefully read and followed in order to realize optimum performance and long useful life of the LV-VSR.

The LV-VSR consists of the following components: Current Limiting Fuses, Overload Relay, and V201 Vacuum Contactor.

- The current limiting fuses, class J AJT600EIB are primary used to provide short-circuit protection to the vacuum contactor. During High-Power testing the V201 vacuum contactor was confirmed to properly coordinate with Ferraz Shawmut type class J AJT600EIB current limiting fuses. The contactor successfully withstood the let-through energy of each fuse for a 200kA available symmetrical fault at 600Vac.

- The overload relay provides longtime overload protection and single phase protection. The solid-state Overload Relay provides high accuracy and enhanced protection through the use of micro-electronic packaging technology. The Overload Relay comes standard with Trip Class 10, 15, and 20 trip characteristics and Manual or Manual/Automatic Reset.

- The V201 Vacuum Contactor is designed for the control of inductive or non-inductive loads at voltages between 200 and 600, ac.

The fuses have a micro-switch mounted to the body of the fuse which provides blown/open indication. This switch opens the contactor and prevents a close operation in the event of a blown/open fuse. This feature also provides single phase protection to the motor.

### WARNING

FERRAZ SHAWMUT TYPE AOS-S MICROSWITCHES AND TYPE AJT600EIB FUSES MUST BE USED TO RETAIN THE IEEE/ANSI CERTIFICATION.

#### 1.1 AVAILABLE MOTOR STARTER REPLACEMENTS

Refer to Table 1.

### WARNING

SATISFACTORY PERFORMANCE OF THESE VACUUM MOTOR STARTER REPLACEMENT UNITS IS CONTINGENT UPON PROPER APPLICATION, CORRECT INSTALLATION AND ADEQUATE MAINTENANCE. THIS INSTRUCTION BOOK MUST BE CAREFULLY READ AND FOLLOWED IN ORDER TO OBTAIN OPTIMUM PERFORMANCE FOR LONG USEFUL LIFE OF THE VACUUM MOTOR STARTER.

**TYPE LV-VSR VACUUM MOTOR STARTER REPLACEMENT UNITS ARE PROTECTIVE DEVICES, AS SUCH, THEY ARE MAXIMUM RATED DEVICES. THEREFORE, THEY SHOULD NOT UNDER ANY CIRCUMSTANCE BE APPLIED OUTSIDE THEIR NAMEPLATE RATINGS.**

All possible contingencies which might arise during installation, operation, or maintenance, and all details and variations of this equipment are not covered by these instructions. If further information is desired by the purchaser regarding a particular installation, operation, or maintenance of this equipment, the local Eaton’s Electrical Services & Systems Representative should be contacted.

---

**Table 1. LV-VSR Vacuum Motor Starter Replacement Unit Availability and Interchangeability**

<table>
<thead>
<tr>
<th>Vacuum Starter Replacement Type</th>
<th>Rated Max. Volts (Vac)</th>
<th>Rated Continuous Current At 60Hz (Amps)</th>
<th>Rated Short Circuit kA RMS At Rated Max. Voltage</th>
<th>Rated Withstand ANSI Test Voltage Low Freq. V RMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-2-25-LV-VSR-425A</td>
<td>600</td>
<td>425</td>
<td>200</td>
<td>2200</td>
</tr>
<tr>
<td>AK-2A-25-LV-VSR-425A</td>
<td>600</td>
<td>425</td>
<td>200</td>
<td>2200</td>
</tr>
<tr>
<td>AK-3A-25-LV-VSR-425A</td>
<td>600</td>
<td>425</td>
<td>200</td>
<td>2200</td>
</tr>
</tbody>
</table>
### Table 2. AK-2-25-LV-VSR Dimensions

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Existing Breaker</th>
<th>Rated Continuous Current at 60 Hz (Amps)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-2-25-LV-VSR</td>
<td>425A</td>
<td></td>
<td>18.05</td>
<td>3.50</td>
<td>5.00</td>
<td>8.00</td>
<td>20.41</td>
<td>17.10</td>
<td>3.55</td>
</tr>
</tbody>
</table>
### Table 3. AK-2A-25 & AK-3A-25 LV-VSR Dimensions (AK-2A-25-LV-VSR Shown)

<table>
<thead>
<tr>
<th>Device Type</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-3A-25-LV-VSR</td>
<td>425A</td>
<td>16.29</td>
<td>3.50</td>
<td>4.50</td>
<td>8.12</td>
<td>20.19</td>
<td>18.00</td>
</tr>
</tbody>
</table>
SECTION 2: SAFE PRACTICES

Vacuum Starter Replacements are designed with several built-in interlocks and safety features to provide safe and proper operating sequences.

⚠️ WARNING

TO PROTECT THE PERSONNEL ASSOCIATED WITH INSTALLATION, OPERATION, AND MAINTENANCE OF THE LV-VSR, THE FOLLOWING PRACTICES MUST BE FOLLOWED:

- Only qualified persons, as defined in the National Electrical Safety Code, who are familiar with the installation and maintenance of low voltage circuits and equipment, should be permitted to work on the LV-VSR.
- Read these instructions carefully before attempting any installation, operation or maintenance of the LV-VSR.
- Always remove the LV-VSR from the enclosure before performing any maintenance. Failure to do so could result in electrical shock leading to death, severe personnel injury or property damage.
- Do not work on a LV-VSR with the secondary test coupler engaged. Failure to disconnect the test coupler could result in an electrical shock leading to death, personnel injury or property damage.
- Do not use a LV-VSR as the sole means of isolating a circuit. Withdraw the LV-VSR to the ‘Disconnect’ position and follow all lockout and tagging rules of the National Electrical Code and any and all applicable codes, regulations and work rules.
- Do not leave the LV-VSR in an intermediate position in the cell. Always have the LV-VSR either in the ‘Disconnect’ or ‘Connect’ position. Failure to do so could result in a flash over and possible death, personnel injury or property damage.
- LV-VSRs are equipped with safety interlocks. Do not defeat them. This may result in death, bodily injury or equipment damage.
SECTION 3: RECEIVING, HANDLING, AND STORAGE

Vacuum Starter Replacements are subjected to complete factory production tests and inspection before being packed. They are shipped in packages designed to provide maximum protection to the equipment during shipment and storage and at same time to provide convenient handling.

3.1 RECEIVING

Until the LV-VSR is ready to be delivered to the switchgear site for installation, DO NOT remove it from the shipping crate. If the LV-VSR is to be placed in storage, maximum protection can be obtained by keeping it in its crate.

Upon receipt of the equipment, inspect the crates for any signs of damage or rough handling. Open the crates carefully to avoid any damage to the contents. Use a nail puller rather than a crow bar when required.

When opening the crates, be careful that any loose items or hardware are not discarded with the packing material. Check the contents of each package against the packing list. Examine the LV-VSR for any signs of shipping damage such as broken, missing or loose hardware, damaged or deformed insulation and other components. File claims immediately with the carrier if damage or loss is detected and notify the nearest Eaton’s Electrical Services & System office.

3.2 HANDLING

**WARNING**

DO NOT USE ANY LIFTING DEVICE AS A PLATFORM FOR PERFORMING MAINTENANCE, REPAIR OR ADJUSTMENT. THE LV-VSR MAY SLIP OR FALL CAUSING SEVERE PERSONAL INJURY. ALWAYS PERFORM MAINTENANCE, REPAIR AND ADJUSTMENTS ON A WORKBENCH CAPABLE OF SUPPORTING THE LV-VSR TYPE.

LV-VSR shipping containers are designed to be handled by a forklift truck. If containers must be skidded for any distance, it is preferable to use roller conveyors or individual pipe rollers.

Once a LV-VSR has been inspected for shipping damage, it is best to return it to its original shipping crate until it is ready to be installed in the Metal-Enclosed Switchgear.

When a LV-VSR is ready for installation, a lifting harness in conjunction with an overhead lift or portable floor lift can be used to move a LV-VSR. If the LV-VSR is to be lifted, position the lifting device (lifting straps should have at least a 1600 pound capacity) over the LV-VSR and insert the lifting harness hooks into the LV-VSR side openings and secure. Be sure the hooks are firmly attached before lifting the LV-VSR. Stand a safe distance away from the LV-VSR while lifting and moving.

3.3 STORAGE

If the LV-VSR is to be placed in storage, maximum protection can be obtained by keeping it in the original shipping crate. Before placing it in storage, checks should be made to make sure that the LV-VSR is free from shipping damage and is in satisfactory operating condition.

Outdoor storage is NOT recommended. If unavoidable, the outdoor location must be well drained and a temporary shelter from sun, rain, snow, corrosive fumes, dust, dirt, falling objects, excessive moisture, etc. must be provided. Containers should be arranged to permit free circulation of air on all sides and temporary heaters should be used to minimize condensation. Moisture can cause rusting of metal parts and deterioration of high voltage insulation.

A heat level of approximately 400 watts for each 100 cubic feet of volume is recommended with the heaters distributed uniformly throughout the structure near the floor.

Indoor storage should be in a building with sufficient heat and circulation to prevent condensation. If the building is not heated, the same general rule for heat as for outdoor storage should be applied.

3.4 LV-VSR APPROXIMATE WEIGHTS

Refer to Table 3.

<table>
<thead>
<tr>
<th>Type</th>
<th>Amperes</th>
<th>LBs</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-2-25-LV-VSR</td>
<td>425A</td>
<td>160</td>
</tr>
<tr>
<td>AK-2A-25-LV-VSR</td>
<td>425A</td>
<td>120</td>
</tr>
<tr>
<td>AK-3A-25-LV-VSR</td>
<td>425A</td>
<td>120</td>
</tr>
</tbody>
</table>

**Figure 3.1. Lifting (AK-2-25-LV-VSR Shown)**
Figure 3.2. Front External View of AK-2-25-LV-VSR

Front External View

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overload Relay Access</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Open Operator</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Contactor Status Indicator</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Contactor Operations Counter</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>Guide Rail</td>
<td></td>
</tr>
</tbody>
</table>

1. Overload Relay Access
2. Open Operator
3. Contactor Status Indicator
4. Contactor Operations Counter
5. Racking Handle
6. Lifting Point
7. Secondary Contacts
8. Handle Pins
9. Guide Rail
10. Lock Out / Tag Out
AK-2-25, AK-2A-25, & AK-3A-25 LV-VSR
Breaker-To-Motor Starter Conversion

Figure 3.3. Rear External View of AK-2-25-LV-VSR

<table>
<thead>
<tr>
<th></th>
<th>Rear External View</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Secondary Contacts</td>
</tr>
<tr>
<td>2</td>
<td>Primary Disconnects</td>
</tr>
<tr>
<td>3</td>
<td>V201 Vacuum Contactor</td>
</tr>
<tr>
<td>4</td>
<td>Guide Rail</td>
</tr>
<tr>
<td>5</td>
<td>Rear Position Stop</td>
</tr>
<tr>
<td>6</td>
<td>Lifting Point</td>
</tr>
<tr>
<td>7</td>
<td>Handle Pins</td>
</tr>
</tbody>
</table>
Figure 3.4. Front External View of AK-2A-25-LV-VSR

Front External View

1 Overload Relay Access  
2 Open Operator  
3 Contactor Status Indicator  
4 Contactor Operations Counter  
5 Lifting Point  
6 Secondary Contacts  
7 Secondary Block Shim  
8 Rollers
Figure 3.5. Rear External View of AK-2A-25-LV-VSR

**Rear External View**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Secondary Contacts</td>
<td>3 V201 Vacuum Contactor</td>
</tr>
<tr>
<td>2</td>
<td>Primary Disconnects</td>
<td>4 Lifting Point</td>
</tr>
</tbody>
</table>
SECTION 4: DESCRIPTION AND OPERATION

Vacuum Contactors

Class V201 NEMA vacuum contactors are designed for the control of inductive or non-inductive loads at voltages between 200 and 600 Vac. The vacuum contactor in the LV-VSR is protected against short-circuits above its capability by current limiting fuses.

General

The V201 contactor has its main contacts sealed inside ceramic tubes from which all air has been evacuated, i.e., the contacts are in vacuum. No arcon boxes are required, because any arc formed between opening contacts in a vacuum has no oxidized air to sustain it. The arc simply stops when the current goes through zero as it alternates at line frequency. The arc usually does not survive beyond the first half cycle after the contacts begin to separate. The ceramic tube with the moving and stationary contacts enclosed is called a vacuum interruptor or a bottle, and there is no such bottle for each pole of the contactor. A three-pole contactor has three vacuum bottles. A metal bellows (like a small, circular accordion) allows the moving contact to be closed and pulled open from the outside without letting air into the vacuum chamber of the bottle. Both the bellows and the metal-to-ceramic seals of modern bottles have been improved to the point that loss of vacuum is no longer cause for undue concern.

The moving contacts are driven by a molded plastic crossbar supported by two pre-lubricated ball bearings that are clamped in alignment for long life and free motion.

The contacts in an unmounted bottle (vacuum interrupter) are normally-closed, because the outside air pressure pushes against the flexible bellows. For contactor duty, the contacts must be “normally-open” when the operating magnet is not energized. Therefore, the contacts of the vacuum bottles must be held apart mechanically against the air pressure when used in a contactor. In the contactor, all of the bottles are held open by a single kickout spring in the rear of the contactor. The kickout spring pulls against the moving armature and crossbar and thereby forces the bottles into the open position. In the open position, the crossbar is pulling the moving contacts to hold them open.

Contact Force and Altitude

A vacuum contactor is affected by atmospheric pressure on the bellows of the vacuum bottles. Up to an altitude of 3300 feet, the contactor is designed to tolerate normal variations in barometric pressure. If the contactor is to be operated over 3300 feet above sea level, consult the factory.

Contact Wear Allowance

Contact material vaporizes from the contact faces during every interruption and condenses inside the bottle. This is normal, and is provided for by overtravel, or wear allowance. When the contactor is fully closed, there is a gap underneath the lower bottle nut and the pivot plate. See Figure 6.1. As the contacts wear, this gap decreases. When any gap goes below .020 in., the unit should be replaced.

Use the .020 in. thick fork-shaped overtravel gauge supplied for this measurement, Part No. 7874A59H01

WARNING

DO NOT RE-ADJUST THE BOTTLE NUTS TO RESET OVERTRAVEL AS THE BOTTLES WEAR. ONCE PLACED INTO SERVICE, OVERTRAVEL SHOULD BE CHECKED BUT NOT ADJUSTED. A STAR-WHEEL LOCK IS INCLUDED FOR LOCKING THE BOTTLE NUTS OF EACH BOTTLE TO PREVENT TAMPERING.

Coil

The operating coil has a “figure-eight” shape and is really two coils in series, with a connection to their common point. Both coils are encapsulated in one environment-immune coil shell, which also contains a full-wave bridge. When ac is connected directly to terminals A and B on the coil shell, the magnet excitation is unfiltered dc. The magnet will not chatter as ac magnets sometimes do, but at less than rated voltage it may hum slightly. A normally-closed Type L63 auxiliary contact, set to open slightly before the armature fully closes, is connected to terminals C and D on the coil shell. When adjusted correctly, this contact allows a relatively high current through the pickup winding, and as the contactor closes, the contact inserts the holding winding, which reduces the coil current to a low value sufficient to hold the magnet closed without overheating. No external resistors are required.

Overload Relay

The Overload Relay provides long-term overload protection and single phase protection. The solid-state Overload Relay provides high accuracy and enhanced protection through the use of micro-electronic packaging technology. The Overload Relay comes standard with trip class 10, 15, and 20 trip characteristics.

Current-Limiting Fuses

The current limiting fuses, class J AJT600IEIB are primary used to provide short-circuit protection to the vacuum contactor. During High-Power testing the V201 vacuum contactor was confirmed to properly coordinate with Ferraz Shawmut type class J AJT600IEIB current limiting fuses. The contactor successfully withstood the throughput energy of each fuse for a 200kA available symmetrical fault at 600Vac.

4.1 ELECTRICAL CONTROL

Specific wiring schematics and diagrams are included with each LV-VSR. (Typical Schematic Shown in Figure 4.1.)

There may be different control voltages or more than one tripping element, but the principle mode of operation is as follows:

If control power is present, and the LV-VSR is either the ‘Test’ or ‘Connect’ position, then the LV-VSR may be closed.

The LV-VSR may be closed by making the control switch close (CS/C) contact. The LV-VSR may be opened any time by making the control switch (CS/T) contacts.

Note the position switch (PS1/DT) contact in the closing circuit. This contact remains open while the LV-VSR is being levered between the ‘Test’ and ‘Connect’ positions. Consequently, it prevents the LV-VSR from closing automatically, even though the control close contact may have been made while the LV-VSR is levered to the ‘Connect’ position. PS1 is open also while the interlock tab is manually pressed or the cell door is open.

When the CS/C contact is made, the MR1 closes the LV-VSR. If the CS/C contact is maintained after the LV-VSR closes, and a trip signal is sent, the Yrelay will close and pick up the Yrelay. The Y/a contact may have been made while the LV-VSR is levered to the ‘Connect’ position. PS1 is open also while the interlock tab is manually pressed or the cell door is open.

Even though the LV-VSR would open, it could not be reclosed before CS/C was released and remade and no trip signal was present. This is the anti-pump function.

The LV-VSR will also open if there was an overload condition that the OL relay sensed. The LV-VSR will not close until the OL relay is reset after an overload condition.

The LV-VSR will also open if a fuse blows or opens. The LV-VSR will not close until the blown or open fuses are replaced.

Trip Free Operation

The LV-VSR is in a “trip-free” condition if the unit is in between the ‘Test’ and ‘Connect’ position. Also, if the local open push button is depressed and maintained, the LV-VSR is in a “trip-free” condition.

4.2 BUSHING & DISCONNECTING CONTACT ASSEMBLIES

The line and load bushing assemblies, which are the primary circuit terminals of the LV-VSR, consist of six tin plated conductors. Multiple finger type primary disconnecting contacts at the ends of the conductors provide means for connecting and disconnecting the LV-VSR to the bus terminals in the switchgear compartment.
4.3 SECONDARY CONNECTION BLOCK

The LV-VSR control circuit is connected to the switchgear control through a multi-contact block. The movable secondary control contacts mounted on the LV-VSR are self-aligning, line-contact, slip-type connectors. The multiple finger arrangement on the LV-VSR makes contact with a stationary mounted element. The contact surfaces on the stationary element are recessed to prevent accidental short-circuiting of the control circuits. These secondary disconnects mate in both the 'Connect' and 'Test' positions.

4.4 INTERLOCKS

There are several interlocks built into the LV-VSR. Each of these interlocks, though different in form, duplicate or exceed in function that of the original breaker. These interlocks exist to safeguard personnel and equipment. The basic premise behind the interlocking arrangement on the LV-VSR is that the LV-VSR must not be inserted into or removed from the live circuit while the main contacts are closed. Also considered in the interlocking is that the LV-VSR should pose no greater risk than necessary to the operator in or out of the cell.

**WARNING**

Interlocks are protective devices for personnel and equipment. Do not bypass, modify, or make inoperative any interlocks. Doing so could cause death, serious personal injury, and/or property damage.
SECTION 5: INSPECTION

⚠️ WARNING

Before placing the LV-VSR in service, carefully follow the installation procedure below and the safe practices set forth in Section 2. Not following the procedure may result in incorrect LV-VSR operation leading to death, bodily injury, and property damage.

This vacuum breaker / starter replacement is not designed to operate a separate external auxiliary switch (MOC switch).

Do not perform manual or electrical operational checks with the LV-VSR in the 'Connect' position because of the possibility of connecting de-energized load circuits to the electrical power source, resulting in death, personal injury or equipment damage.

Do not attempt to install or operate a LV-VSR until a vacuum integrity test is performed.

⚠️ DANGER

Non-interchangeable vacuum breaker / starter replacement

5.1 EXAMINATION FOR DAMAGE

Examine the LV-VSR for loose or obviously damaged parts. Never attempt to install nor operate a damaged LV-VSR.

When the LV-VSR is first commissioned into service and each time the LV-VSR is returned to service, it should be carefully examined and checked to make sure it is clean and operating correctly.

5.1.1 NAMEPLATE VERIFICATION

Compare the LV-VSR nameplate information with switchgear drawings for compatibility.

5.1.2 CURRENT LIMITING FUSES

The LV-VSR contains current limiting fuses. The primary purpose of the fuse is to protect the V201 vacuum contactor. The fuses can interrupt faults up to 200,000 Amperes RMS symmetrical current.

The fuses are Ferraz Shawmut type J AJT600EIB current limiting. Do not replace the fuses with any other type fuse. The fuses have been tested in conjunction with the V201 vacuum contactor.

Blown Fuse Indication

The fuses have a micro-switch mounted on the body of the fuse. This switch activates when a fuse blows. If the LV-VSR experiences a condition which causes the fuse to interrupt current, then the switch will activate, trip and lock out the V201 vacuum contactor. Any attempt to close the contactor with a blown fuse will be prevented until the fuse is replaced.

Replacing Fuses

To replace a blown fuse, follow the removal procedure in Section 5.5 to the removal of the LV-VSR from the switchgear. Once the LV-VSR is removed from the switchgear and placed outside of the Arc-Flash boundary, follow these steps:

1. Place the LV-VSR on a stable surface.
2. Remove the four fasteners from the top barrier.
3. Remove the top barrier and set aside.

4. Locate the blown fuse or fuses.
5. Remove the micro-switch from the blown fuse. To remove the switch, use a flat blade screwdriver to gently pry the switch from its mounting base.
6. Remove the two fasteners from the blown fuse. Take special notice of the orientation of the fuse.
7. Remove the blown fuse from the LV-VSR.
8. Install the new replacement fuse with the same orientation in place of the removed blown fuse.
9. Insert the fasteners with a flat washer into the mounting hole of the fuse; use a retaining nut with a lock washer and flat washer to tighten the fuse to the connecting copper.
10. Tighten the fasteners using a wrench to hold the head of the screw while tightening the retaining nut. DO NOT over tighten.
11. Torque the fasteners to 50 ft-lbs.
12. Replace the micro-switch to the fuse by gently pressing the switch on to the mounting base.
13. Check the connections of the control wiring on the micro-switch, if loose, tightening with a Phillips head screwdriver.
14. Install the top barrier back onto the LV-VSR.
15. Insert the four fasteners into the top barrier and tighten until snug.
16. Electrically test the LV-VSR by using a test cabinet device or equivalent. Make sure the LV-VSR will close and open normally.
17. Perform an ac hipot test per section 6 prior to insertion into the switchgear.
18. Check the V201 contactor per section 6.3.2 prior to insertion.

**WARNING**
ALWAYS INSPECT THE LV-VSR AFTER ANY SHORT-CIRCUIT INTERRUPTION. FAILURE TO DO SO MAY RESULT IN EQUIPMENT DAMAGE AND OR DEATH.

5.2 ELECTRONIC OVERLOAD RELAY C440

The preferred overload relay provided on Eaton LV-VSR devices is the electronic C440 relay. The relay offers four selections of trip classes:

1. The C440 overload device normally specified for the LV VSR devices is the relay that provides two trip class selections, 10 or 20, plus a switchable ground fault trip system. The ground fault trip threshold is 50% of the full load ampere setting. See Figures 5.4 and 5.5.

**Figure 5.4. C440 Overload Relay Faceplate and Functions**

*Figure 5.5. Ground Fault Unit*

3Ø Systems only
GF 50% FLA Setting

<table>
<thead>
<tr>
<th>Trip Class</th>
<th>10</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLA Setting</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

2. A second rarely used C440 overload relay is available in a 3-phase and single phase form. The 3-phase and single phase configured device allows four trip class selections: 10, 20, 30, and 10A. Figure 5.6 shows the C440 with four trip class selections.

3. Refer to Figure 5.5 or 5.6. C440 relay features include a push/pull button for trip and test, a push button for reset, and the full load current dial. Adjacent to the FLA dial, the C440 electronic overload relay has ‘dip’ switch selections for trip classes 10 or 20. (Most applications conforming to ANSI guidelines use trip class 20.) The second position enables or disables the built-in ground fault trip system. The third position of the ‘dip’ switch enables or disables the phase unbalance protection of the device. The fourth position of the ‘dip’ switch enables or disables automatic reset of the relay (see special warning about using automatic reset feature). An indicating light on the face of the relay signals when current is passing through the LV-VSR and when a trip has occurred. Rapid blinking of the indicating light on the C440 indicates that trip is imminent. Make the preferred ‘dip’ switch selections prior to energizing the LV VSR for the first time.

**Figure 5.6. C440 Trip Current Adjustment and DIP Switches**

<table>
<thead>
<tr>
<th>DIP Switch Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LED (Unit Status)</td>
</tr>
<tr>
<td>2</td>
<td>FLA Dial</td>
</tr>
<tr>
<td>3</td>
<td>Phase Imbalance Selection</td>
</tr>
<tr>
<td>4</td>
<td>Operating Modes (Trip/Reset/Test)</td>
</tr>
</tbody>
</table>

**Figure 5.7. Motor Service Factor Information for the C440 Overload Relay**

Overload Tripping Current = 115%

Rotate FLA dial to current listed on motor nameplate for all motor Service Factors.
4. A Full Load Current (FLA) dial is provided for selecting the full load current setting, calculated based on the current transformer ratio of the current transformers installed on the LV VSR and the full load current determined from the motor nameplate. When the C440 is set correctly, the relay will provide tripping at 115% of the motor full load rating in less than 10 seconds in accordance with UL 508. The C440 provided has markings 1 through 5 corresponding to the 5 ampere secondary current of the current transformers. These markings designate trip thresholds that correspond to the current passing through the windows of the current transformers mounted on the rear of the LV VSR. Selections are possible over the full range of the dial. The trip setting must be made according to item 6 below prior to energizing the LV VSR for the first time.

5. An electrically separate normally open (NO) contact and an electrically separate normally closed (NC) contact are provided. See Figure 5.9 for operating modes. The C440 may be optionally equipped with various communication modules to allow remote functionality over Modbus, DeviceNet, ProfiBus, and Ethernet IP communication protocols.

6. Eaton LV VSRs are equipped with 300:5 or 600:5 current transformers as required by the continuous current rating shown on the nameplate of the device. The current transformer ratio and motor full load current must be known to determine the proper FLA dial setting on the C440 relay. That setting may be calculated by the following formula:

   \[ \text{Set Value} = \text{Equivalent FLA} \times \left( \frac{1}{\text{CT Ratio}} \right) \]

   \[ \text{Example: CT ratio is 300:5} \quad 300/5 = 60 \]

   Motor FLC is 120 amperes

   \[ \text{Set Value} = 120 \times \left( \frac{1}{60} \right) = 2.0 \]

   \[ \text{Table 6. C440 Overload Relay Dial Settings} \]

<table>
<thead>
<tr>
<th>Overload Relay Dial Settings</th>
<th>FLA with 300:5 CT</th>
<th>FLA with 600:5 CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>1.25</td>
<td>75</td>
<td>150</td>
</tr>
<tr>
<td>1.50</td>
<td>90</td>
<td>180</td>
</tr>
<tr>
<td>1.75</td>
<td>105</td>
<td>210</td>
</tr>
<tr>
<td>2.00</td>
<td>120</td>
<td>240</td>
</tr>
<tr>
<td>2.25</td>
<td>135</td>
<td>270</td>
</tr>
<tr>
<td>2.50</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>2.75</td>
<td>165</td>
<td>330</td>
</tr>
<tr>
<td>3.00</td>
<td>180</td>
<td>360</td>
</tr>
<tr>
<td>3.25</td>
<td>195</td>
<td>390</td>
</tr>
<tr>
<td>3.50</td>
<td>210</td>
<td>420</td>
</tr>
<tr>
<td>3.75</td>
<td>225</td>
<td>Exceeds VSR Current Rating</td>
</tr>
<tr>
<td>4.00</td>
<td>240</td>
<td>Exceeds VSR Current Rating</td>
</tr>
<tr>
<td>4.25</td>
<td>255</td>
<td>Exceeds VSR Current Rating</td>
</tr>
</tbody>
</table>

   \[ \text{Table 6. C440 Overload Relay Dial Settings} \]

   \[ \text{Set Value} = \text{Equivalent FLA} \times \left( \frac{1}{\text{CT Ratio}} \right) \]

   \[ \text{Example: CT ratio is 300:5} \quad 300/5 = 60 \]

   Motor FLC is 120 amperes

   \[ \text{Set Value} = 120 \times \left( \frac{1}{60} \right) = 2.0 \]

**Figure 5.8. Average Hot Trip Curve for Three Phase Motors**

![Average Hot Trip Curve](image)

Consult factory or Eaton website for cold trip curves.

The C440 FLA setting may also be determined from Table 6.

**Note:** The overload relay allows trip settings that exceed the 425 ampere continuous current rating of the LV VSR. Therefore, dial settings above 3.5 are not allowed.

7. Figures 5.5 and 5.6 are provided for setting assistance. For the C440, the overload relay settings are the same regardless of motor service factor.

**Note:** The LV VSR is shipped from the Power Breaker Center with its overload relay set at the very lowest setting; the C440 must be properly set before closing the device onto a motor load.

8. Figure 5.8 provides hot motor time-current information for the C440.

9. Eaton Instructional Leaflet IL04210001E provides additional information on the C440 overload relay.

10. If the C440 overload relay trips after a motor overload condition, access the relay through the removable front clear polycarbonate cover, and press the reset button. The device should only be reset after the condition causing the motor overload is removed.

**Table 6. C440 Overload Relay Dial Settings**

<table>
<thead>
<tr>
<th>Overload Relay Dial Settings</th>
<th>FLA with 300:5 CT</th>
<th>FLA with 600:5 CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>1.25</td>
<td>75</td>
<td>150</td>
</tr>
<tr>
<td>1.50</td>
<td>90</td>
<td>180</td>
</tr>
<tr>
<td>1.75</td>
<td>105</td>
<td>210</td>
</tr>
<tr>
<td>2.00</td>
<td>120</td>
<td>240</td>
</tr>
<tr>
<td>2.25</td>
<td>135</td>
<td>270</td>
</tr>
<tr>
<td>2.50</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>2.75</td>
<td>165</td>
<td>330</td>
</tr>
<tr>
<td>3.00</td>
<td>180</td>
<td>360</td>
</tr>
<tr>
<td>3.25</td>
<td>195</td>
<td>390</td>
</tr>
<tr>
<td>3.50</td>
<td>210</td>
<td>420</td>
</tr>
<tr>
<td>3.75</td>
<td>225</td>
<td>Exceeds VSR Current Rating</td>
</tr>
<tr>
<td>4.00</td>
<td>240</td>
<td>Exceeds VSR Current Rating</td>
</tr>
<tr>
<td>4.25</td>
<td>255</td>
<td>Exceeds VSR Current Rating</td>
</tr>
</tbody>
</table>

**Phase Imbalance Selection for C440**

When a three phase load is powered with a poor quality line, the voltage per phase may be unbalanced.

The effect of this if not protected results in unbalanced voltage which causes large unbalanced currents. It can also lead to motor stator windings being overloaded, causing excessive heating, reduced motor efficiency and reduced insulation life.

If the OL relay is switched to the “ON” position, it will take the starter offline if a phase drops below 50% of the other two phases.

**Figure 5.9. Operating Modes for C440**

- TRIP: Pull Red Button “click”
- RESET: Push Blue Reset Button “click”
- TEST: Push Red Button “no click” * Approximately 1 lbf
5.3 MANUAL OPERATIONAL CHECK

Manual operational checks must be performed before the LV-VSR is connected to a live circuit. Manual operational checks can be performed with the LV-VSR in the ‘Test’ position in the cell or outside of the cell, as long as secondary power is available.

5.4 ELECTRICAL OPERATIONAL CHECKS

**WARNING**

DO NOT PERFORM ELECTRICAL OPERATION CHECKS WITH THE LV-VSR IN THE ‘CONNECT’ POSITION BECAUSE OF THE POSSIBILITY OF CONNECTING DE-ENERGIZED LOAD CIRCUITS TO THE ELECTRICAL POWER SOURCE, RESULTING IN DEATH, PERSONNEL INJURY OR EQUIPMENT DAMAGE.

The LV-VSR can only be operated electrically when the following conditions are met:

1. Control power is present, either by having the LV-VSR in the ‘Test’ position in the cubicle or by a test cabinet connected to the LV-VSR.
2. The overload relay reset if tripped.
3. The current limiting fuses are not blown.

Having met these conditions, the LV-VSR may be electrically operated.

There is no provision to close the LV-VSR locally on the unit. The close signal must be applied remotely or by a control switch located at the switchgear.

To open the LV-VSR, either send a remote open signal, press the trip plate on the LV-VSR, or press the test button on the overload relay.

Perform several close/open operations to ensure reliable and constant electrical operation.

**WARNING**

DO NOT ATTEMPT TO INSTALL OR OPERATE A LV-VSR UNTIL A VACUUM INTEGRITY TEST IS PERFORMED.

Move the LV-VSR to an area with adequate room, and outside the Arc-Flash boundary for the following tests:

Vacuum Integrity Checks

Using a dry lint-free cloth or a paper towel, clean all of the insulating surfaces on the LV-VSR. Check the vacuum integrity of the interrupters of the three vacuum bottles by conducting the applied potential test as described in Section 6 of this manual.

Low Frequency Withstand Test

Check the LV-VSR primary and secondary insulation integrity by conducting the applied potential test as described in Section 6.

Contact Inspection

Contact Wear allowance and mechanical checks on the V201 Vacuum Contactor are described in Section 6.

Primary Circuit Resistance

Testing that measures the primary circuit resistance is not recommended since the results can vary widely on good contacts. It is measured at the factory prior to shipment. If a resistance check is required check the primary resistance described in Section 6.
SECTION 5.A: INSTALLATION OF AK-2-25 LV-VSR

5.A.1 CELL MODIFICATION INSTRUCTIONS

⚠️ WARNING

FAILURE TO COMPLETE THE FOLLOWING CELL CODING MODIFICATION TO EACH CELL INTENDED TO RECEIVE THIS SPECIFIC BREAKER-TO-MOTOR STARTER REPLACEMENT (VSR) CAN RESULT IN DAMAGE TO THE VSR, DAMAGE TO THE SWITCHGEAR AND ATTACHED EQUIPMENT AND COULD RESULT IN BODILY INJURY OR DEATH. DO NOT PERFORM THESE MODIFICATIONS ON AN ENERGIZED CELL.

IF THE CELL CAN NOT BE DE-ENERGIZED, THEN PROPER NFPA 70E PERSONAL PROTECTIVE EQUIPMENT MUST BE WORN AT ALL TIMES WHILE PERFORMING THE CELL CODING MODIFICATION. FAILURE TO COMPLY WITH THIS WARNING COULD CAUSE SEVERE PERSONNEL INJURY, EQUIPMENT DAMAGE, OR DEATH.

1. Place the cell code/rejection cutting template into the right hand channel of the switchgear. The block on the back of the cell code/rejection cutting template will be on the inside of the switchgear with the right edge of it resting on the lever-in bracket located in the switchgear. The slot in the cell code/rejection cutting template fits over the protruding channel web. (Figure 5.A.1)

2. Using a felt tip pen mark the right lip of the switchgear using the cutout located in the cell code/rejection cutting template. (Figure 5.A.2)

3. Remove the cell code/rejection Cutting Template from the switchgear.

4. Using the appropriate tools cut out the area marked in step 2. Do not cut on the mark, just cut up to the mark, being careful not to cut past the mark.

5. Use a file to clean rough edges from cut out. Clean all metal shavings after modification has been completed. (Figure 5.A.3)

6. After performing the cell coding modification the LV-VSR may be inserted into the switchgear. (See Section 5.A.3 for the insertion procedure.) The modification does allow the insertion of a circuit breaker, but the absence of the cell coding modification prevents the LV-VSR from being inserted into a normal feeder breaker cell structure.

7. Since the LV-VSR unit is for use in existing metal-enclosed switchgear, insertion procedures are similar.

5.A.2 COMPARTMENT DOOR MODIFICATIONS

The four studs located on the inside of the compartment door must be cut down to be 7/16” long, if present, due to interference with the new starter replacement. Use the appropriate tools to cut off these studs to length. See Figure 5.A.4, door with studs.

Figure 5.A.1. Installing Cell Modification Template

Figure 5.A.2. Marking The Cutting Area With Marker

Figure 5.A.3. Smoothing The Cut Area With A File

Figure 5.A.4. Compartment Door Modifications
5.A.3 INSERTION PROCEDURE

WARNING

ARC-FLASH INCIDENCES WITH LV SWITCHGEAR CAN OCCUR DURING THE PROCESS OF INSERTING AND REMOVING LV-VSR DEVICES IN SWITCHGEAR CUBICLES. IT IS STRONGLY RECOMMENDED THAT PROPER PPE (PERSONAL PROTECTIVE EQUIPMENT) BE WORN BY PERSONNEL WHO RACK LV-VSRS.

BEFORE PLACING THE LV-VSR IN SERVICE, CAREFULLY FOLLOW THE INSTALLATION PROCEDURE BELOW AND THE SAFE PRACTICES SET FORTH IN SECTION 2. NOT FOLLOWING THE PROCEDURE MAY RESULT IN INCORRECT LV-VSR OPERATION LEADING TO DEATH, BODILY INJURY, AND PROPERTY DAMAGE.

THIS VACUUM BREAKER / STARTER REPLACEMENT IS NOT DESIGNED TO OPERATE A SEPARATE EXTERNAL AUXILIARY SWITCH (MOC SWITCH).

DO NOT PERFORM MANUAL OR ELECTRICAL OPERATIONAL CHECKS WITH THE LV-VSR IN THE 'CONNECT' POSITION BECAUSE OF THE POSSIBILITY OF CONNECTING DE-ENERGIZED LOAD CIRCUITS TO THE ELECTRICAL POWER SOURCE, RESULTING IN DEATH, PERSONAL INJURY OR EQUIPMENT DAMAGE.

DO NOT ATTEMPT TO INSTALL OR OPERATE A LV-VSR UNTIL A VACUUM INTEGRITY TEST IS PERFORMED.

INSERTION:

1. Ensure that the starter is open.
2. Place the Starter on the channels of the switchgear enclosure with the guides on the sides of the starter level with the channels. Slide the Starter part way into the enclosure. The Starter will be obstructed by a position stop at the bottom of the enclosure after the Starter has traveled only a short distance into the enclosure. (Figure 5.A.5) To move the Starter into the 'Test' position, lift the position stop handle located at the bottom right of the enclosure. This will release the position stop and allow the starter to move further into the enclosure.
3. Lift the racking handle forward (Figure 5.A.9 & 5.A.10) and up as far as its travel will allow and push the Starter into the enclosure until the racking pins on the handle assembly bear against the housing racking cams on the side of the switchgear enclosure.

Figure 5.A.5. Lifting Position Stop Handle

Figure 5.A.6. Initiating The Racking Arm On The AK-2-25-LV-VSR

Figure 5.A.7. Lifting Racking Handle On the AK-2-25-LV-VSR

Figure 5.A.8. AK-2-25-LV-VSR Clearance With Cell Modification
4. Push downward on the racking handle and force the pins on the handle up into the slot in the stationary cam plate. (Use caution not to pinch fingers between racking handle and body of the Starter) This forces the Starter through the final portion of its movement into the enclosure and allows the operator to provide the force necessary to make the primary disconnects engage the primary stabs in the enclosure. While performing this operation make sure that the handle is rotated downwards as far as its free travel will permit and then pull the racking handle down to be sure the trip interlock is released. When the racking handle is in any position other than completely down, the Starter cannot be operated.

5. The Starter is now in the 'Connect' position and can be operated. (Figure 5.A.10)

5.A.4 REMOVAL PROCEDURE

| **DANGER** |
| LV-VSR MUST BE IN THE OPEN POSITION PRIOR TO OPENING CELL DOOR. FAILURE TO DO SO MAY CAUSE SEVERE INJURY, DEATH, OR EQUIPMENT DAMAGE. |

1. Either remotely or locally open the LV-VSR prior to attempting to remove it from the switchgear enclosure.
2. Open the cell door.
3. Pull the racking handle up and forward (use caution not to pinch fingers between racking handle and body of starter) until it has reached the end of it's travel. This will disengage the LV-VSR from the primary disconnects.
4. Slide the starter out by pulling on the racking handle until the starter engages the front position stop located in the bottom pan of the starter. The starter is now in the 'Test' position.
5. Lift the position stop handle and slide the starter forward until the starter reaches the rear position stop also located on the bottom of the starter. In this position both the primary and secondary contacts have been disengaged.
6. Lift the position stop handle again and slide the starter forward in order to remove it from the switchgear enclosure.
AK-2-25, AK-2A-25, & AK-3A-25 LV-VSR
Breaker-To-Motor Starter Conversion

SECTION 5.B: INSTALLATION OF AK-2A-25 LV-VSR

5.B.1 CELL MODIFICATION INSTRUCTIONS

⚠️ WARNING

FAILURE TO COMPLETE THE FOLLOWING CELL CODING MODIFICATION TO EACH CELL INTENDED TO RECEIVE THIS SPECIFIC BREAKER-TO-MOTOR STARTER REPLACEMENT (VSR) CAN RESULT IN DAMAGE TO THE VSR, DAMAGE TO THE SWITCHGEAR AND ATTACHED EQUIPMENT AND COULD RESULT IN BODILY INJURY OR DEATH. DO NOT PERFORM THESE MODIFICATIONS ON AN ENERGIZED CELL.

IF THE CELL CAN NOT BE DE-ENERGIZED, THEN PROPER NFPA 70E PERSONAL PROTECTIVE EQUIPMENT MUST BE WORN AT ALL TIMES WHILE PERFORMING THE CELL CODING MODIFICATION. FAILURE TO COMPLY WITH THIS WARNING COULD CAUSE SEVERE PERSONNEL INJURY, EQUIPMENT DAMAGE, OR DEATH.

IMPORTANT NOTE: THE LEFT TRACK IS MODIFIED FOR 425 AMP SIZE STARTERS. THE RIGHT TRACK IS MODIFIED FOR 120 AMP SIZE STARTERS.

1. Pull the track to be modified out to the limit of its travel and install the cell cutting template assembly so that the mounting pins drop into the existing slots in the track. (Figure 5.B.1)

2. Matching the holes in the clamping plate and drilling template, mount the clamping plate on the opposite side of the track using the hardware provided. This is a temporary installation therefore no torque value is needed.

3. Using a ½” drill bit, drill the hole in the cradle arm with the drill bushing as a guide for the drill bit. The leftmost drill bushing is the guide for 425 amp starters, the rightmost drill bushing will be used as a guide on 120 amp size starters.

Figure 5.B.1. AK-2A-25-L V-VSR Cell Modification (425A Modification Shown)

5.B.2 INSERTION PROCEDURE

Note: The secondary blocks are factory equipped with shims on both sides of the LV-VSR (Figure 3.4). If the secondary blocks are not at the correct distance and cause interference, remove the shims by removing the three .25-20 screws and washers on each side and then the shim. Reinstall the screws and washers as they were (the shim can be mounted to the opposite side of the secondary mounting bracket in case it is needed in the future).

1. Place the jackscrew shaft handle on the jackscrew shaft which is located on the left side of the compartment. (Figure 5.B.2)

2. Turn the jackscrew shaft handle counter clockwise until jackscrew is stopped. The position indicator should indicate that the Starter is in the “DISC” (“Disconnect”) position.

3. Remove the jackshaft handle from the shaft and open enclosure door.

Figure 5.B.2. Jackscrew Shaft on AK-2A-25-LV-VSR Cell

4. Pull the right track out to its limit by rotating the two track lock links and pulling on the track as far out as it will move. (Figure 5.B.3)

5. Raise the Starter using a lifting device until the mounting pins are approximately one inch above the tracks.

6. Pull the left track to its limit of travel and lower the Starter so that the pins on each side of the starter drop into the slots located in the track. Remove the lifting device.

7. Push the Starter in until the track stops. Lock the two track lock links into place and close compartment door.

Figure 5.B.3. Extending Rails of AK-2A-25-LV-VSR Cell
\section*{WARNING}

\textbf{WHEN MOVING A STARTER BETWEEN POSITIONS, BE SURE THE STARTER IS TRIPPED OPEN.}

8. To place the Starter in the ‘Test’ position, insert the handle onto the jackscrew shaft and turn the crank clockwise until the position indicator reads ‘Test’. (Figure 5.B.4) In this position the primary contacts are not made but the secondary contacts are connected. Tests not involving primary power can be executed in this position. The door may be closed to make tests in this position.

\section*{5.B.3 REMOVAL PROCEDURE}

\section*{WARNING}

LV-VSR MUST BE IN THE OPEN POSITION PRIOR TO OPENING CELL DOOR. FAILURE TO DO SO MAY CAUSE SEVERE INJURY, DEATH, OR EQUIPMENT DAMAGE.

1. Either remotely or locally open the LV-VSR prior to attempting to remove it from the switchgear enclosure.
2. Insert the jackscrew handle onto the shaft located on the left side of the enclosure above the position indicator.
3. Rotate the jackscrew handle counter-clockwise from the ‘Connect’ position, through the ‘Test’ position and stop when the position indicator reads DISC and the crank can no longer turn.
4. Remove handle and open enclosure door.
5. Pull the Starter out to its limits by rotating the two rack lock links and pulling outward to the limit of the track travel.
6. Lift the Starter up and away with a suitable lifting device. At this point the primary disconnects should clear the enclosure.
7. The Starter is now separate from the enclosure.

\textbf{Note:} Padlocking has been provided by the original equipment manufacturer.

9. To move the Starter into the ‘Connect’ position, insert the handle on the jackscrew shaft and turn clockwise until it can no longer be rotated. The position indicator should read ‘Connect’. In this position both primary and secondary contacts are made and the door can be closed. (Figure 5.B.5)
SECTION 6: INSPECTION AND MAINTENANCE

6.1 INTRODUCTION

⚠️ WARNING

- DO NOT WORK ON A LV-VSR IN THE ‘CONNECT’ POSITION.
- DO NOT WORK ON A LV-VSR WITH SECONDARY DISCONNECTS ENGAGED.
- DO NOT WORK ON A LV-VSR WITH THE CONTACTOR CLOSED.
- DO NOT DEFEND ANY SAFETY INTERLOCKS.
- FOLLOW ALL PRECAUTIONARY MEASURES WHEN TESTING FOR VACUUM INTEGRITY.
- FAILURE TO FOLLOW ANY OF THESE INSTRUCTIONS MAY CAUSE DEATH, SERIOUS BODILY INJURY, OR PROPERTY DAMAGE. SEE SECTION 2 - SAFE PRACTICES FOR MORE INFORMATION.

6.2 FREQUENCY OF INSPECTION

Inspect the LV-VSR once a year when operating in a clean, non-corrosive environment. For a dusty and/or corrosive environment, inspection should be performed twice a year. Additionally, it is recommended to inspect the LV-VSR every time it interrupts fault current.

The no-load life test value of the LV-VSR is hundreds of thousands of operations. This value will be reduced if proper inspection, maintenance, and cleaning is not performed.

Refer to Section 6.3 for maintenance and inspection check points.

6.3 INSPECTION & MAINTENANCE PROCEDURES

Inspection and maintenance procedures are recommended to be performed outside of the cell.

⚠️ CAUTION

SOME COMMERCIAL CLEANING AGENTS WILL DAMAGE THE NAMEPLATES OR MOLDED PARTS. MAKE SURE THAT CLEANING AGENTS OR SOLVENTS USED ARE SUITABLE FOR THE JOB.

6.3.1 V201 CONTACTOR

⚠️ NOTICE

THERE ARE NO FIELD SERVICEABLE PARTS ON CONTACTORS.

⚠️ WARNING

THE ONLY WAY TO CLOSE THE CONTACTOR IS TO ENERGIZE THE COIL. IF THE COIL IS ENERGIZED FOR THIS OR OTHER MAINTENANCE, USE ADEQUATE CARE TO GUARD AGAINST ELECTRICAL SHOCK.

6.3.2 CONTACT WEAR ALLOWANCE

Contact material vaporizes from the contact faces during every interruption and condenses inside the bottle. This is normal and is provided for by over-travel or wear allowance. When the contactor is fully closed, there is a gap between the pivot plate and the bottle nuts. As the contacts wear, this gap decreases. When any gap goes below 0.020 inches, the unit should be replaced. Use the 0.020 inch thick fork shaped over-travel gauge supplied for this measurement, Part Number 7874A59H01. Figure 6-1.

⚠️ WARNING

DO NOT READJUST THE BOTTLE NUTS TO RESET OVER-TRAVEL AS THE BOTTLES WEAR. ONCE PLACED INTO SERVICE, OVER-TRAVEL SHOULD BE CHECKED BUT NOT ADJUSTED.

6.3.3 MECHANICAL CHECKS

⚠️ WARNING

THE MECHANICAL CHECKS MAY ONLY BE PERFORMED OUTSIDE THE SWITCHGEAR CELL.

Use a test cabinet to operate LV-VSR. Operate the appropriate push buttons to close and open the contactor. While the contactor is closed, observe the overtravel gap between the pivot plates on the crossbar and the bottle nut on each pole. This overtravel gap should be no less than 0.045 inch when the contactor is new. If less, refer to Contact Wear Allowance section of this manual.

While the contactor is open, attempt to pull the armature forward. The armature should not move because it should already be firmly against the plastic main frame. If it does move, refer to Kickout Spring Adjustment section in this manual.

6.3.4 KICKOUT SPRING ADJUSTMENT

The kickout spring is not disturbed by any maintenance described in this manual, and should not need any adjustment. However, when the contactor is in the open position, the crossbar should be solidly against the frame, so that it cannot move any further open even when pulled. If kickout spring is out of adjustment, call your closest Eaton representative.
6.3.5 INSPECTION AFTER SHORT CIRCUIT

The magnitude of a short circuit may exceed the damage threshold of the vacuum bottle on the V201 contactor. After a short circuit, the unit should be examined for any apparent physical damage, or deformation of conductor bars. If there is any evidence of severe stress, it is recommended that the unit be replaced. If the overtravel has changed significantly (from the last inspection) on one or more bottles, the unit should be replaced.

A dielectric test may be performed at 1760V (80% of factory test level) See Section 6.8. A dielectric test would not by itself confirm that the unit should be returned to service after a fault. Vacuum Integrity is to be performed at 5.5kV ac RMS per section 6.4. However, if there is no physical evidence of stress, and if the overtravel exceeds the 0.020 inch minimum, the bottles can then be dielectrically tested as outlined in this manual. If physical stress, over-travel, and dielectric are satisfactory, it is reasonable to return the unit to service after a fault and after unit has been properly cleaned.

6.4 VACUUM INTERRUPTER INTEGRITY TEST

Vacuum interrupters used in LV-VSR are highly reliable interrupting contactors. Satisfactory performance of these devices is dependent upon the integrity of the vacuum in the interrupter and the internal dielectric strength. Both of these parameters can be readily checked by a one minute ac high potential test. (See Table 6.1) During this test, the following warning must be observed:

Only use an ac high potential test set. A dc high potential test may result inaccurate test results.

⚠️ WARNING

APPLYING ABNORMALLY HIGH VOLTAGE ACROSS A PAIR OF CONTACTS IN VACUUM MAY PRODUCE X-RADIATION. THE RADIATION MAY INCREASE WITH THE INCREASE IN VOLTAGE AND/OR DECREASE IN CONTACT SPACING. X-RADIATION PRODUCED DURING THIS TEST WITH RECOMMENDED VOLTAGE AND NORMAL CONTACT SPACING IS EXTREMELY LOW AND WELL BELOW MAXIMUM PERMITTED BY STANDARDS. HOWEVER, AS A PRECAUTIONARY MEASURE AGAINST POSSIBILITY OF APPLICATION OF HIGHER THAN RECOMMENDED VOLTAGE AND/OR BELOW NORMAL CONTACT SPACING, IT IS RECOMMENDED THAT ALL OPERATING PERSONNEL STAND AT LEAST ONE METER AWAY IN FRONT OF THE LV-VSR.

1. Conduct test with the LV-VSR open and securely placed on a workbench or suitable surface.
2. Short the Current Transformers and the secondary block connections to ground.
3. Connect all top primary studs (bars) together and the high potential machine lead.
4. Connect all bottom studs together. Do not ground them to the LV-VSR frame, connect the high potential ground to the bottom studs.
5. Start the machine at zero potential, increase to appropriate test voltage and maintain for one minute.
6. Successful withstand indicates that all interrupters have satisfactory vacuum level. If there is a breakdown, the contactor should be replaced before placing the LV-VSR in service.
7. After the high potential is removed, discharge any electrical charge that may be retained, particularly from the center shield of vacuum interrupters. To avoid any ambiguity in the ac high potential test due to leakage or displacement (capacitive) current, the test unit should have sufficient volt-ampere capacity. It is recommended that the equipment be capable of delivering 25 milliamperes for one minute.
8. Remove ALL shorting wire on Current Transformers and secondary block before placing unit back into service.

6.5 INSULATION

In LV-VSRs, insulation maintenance primarily consists of keeping all insulating surfaces clean. This can be done by wiping off all insulating surfaces with a dry lint free cloth. In case there is any tightly adhering dirt that will not come off by wiping, it can be removed with a mild solvent or distilled water. Be sure that the surfaces are dry before placing the LV-VSR in service. If a solvent is required to cut dirt, use isopropyl alcohol. Secondary control wiring requires inspection for tightness of all connections and damage to insulation.

6.6 INSULATION INTEGRITY CHECK

PRIMARY CIRCUIT:

The integrity of primary insulation may be checked by the ac high potential test. The test voltage is 1760 V RMS, 60 Hz. Conduct the test as follows:

1. Conduct test with the LV-VSR open and securely placed on a workbench or suitable surface.
2. Ground the LV-VSR frame.
3. Short the Current Transformers connections to ground.
4. Close the Contactor on the LV-VSR. Control power will be needed to close the Contactor.
5. Connect the high potential lead of the test machine to one of the phases of the LV-VSR.
6. Connect the remaining two phases and LV-VSR frame to ground.
7. Start the test machine with output potential at zero and increase to the test voltage. Maintain the test voltage for one minute.
8. Repeat for the remaining phases. Successful withstand indicates satisfactory insulation strength of the primary circuit.
9. Disconnect the control power from the LV-VSR.
10. After the control power has been removed and disconnected from the LV-VSR. Short all of the secondary connections together and to the frame.
11. Connect the high potential lead of the test machine to one of the poles of the LV-VSR.
12. Connect the remaining poles and LV-VSR frame to ground.
13. Start the test machine with output potential at zero and increase to the test voltage. Maintain the test voltage for one minute.
14. Repeat for the remaining poles. Successful withstand indicates satisfactory insulation strength of the primary circuit.
15. Remove ALL shorting wire on the current transformers and secondary block before placing unit back in to service.

⚠️ WARNING

FAILURE TO REMOVE ALL SHORTING WIRE FROM CURRENT TRANSFORMERS AND SECONDARY CONNECTIONS MAY CAUSE INJURIES AND EQUIPMENT DAMAGE.
SECONDARY CIRCUIT:

**WARNING**

BEFORE PERFORMING SECONDARY INSULATION CHECK PLACE A JUMPER ON THE CONTACTOR COIL ASSEMBLY POINTS (A) TO (B). FAILURE TO DO SO MAY RESULT IN DAMAGE TO THE SOLID STATE RECTIFIER IN THE COIL ASSEMBLY.

1. Ensure that a jumper is placed on contactor coil assembly points (A) to (B).
2. Connect all points of the secondary disconnect pins with a shorting wire.
3. Connect Current Transformers with a shorting wire and connect them to the frame.
4. Connect the high potential lead of the test machine to the secondary block.
5. Ground the LV-VSR frame.
6. Starting with zero, increase the voltage to 1200 Vac RMS, 60 Hz. Maintain the voltage for one minute.
7. Successful withstand indicates satisfactory insulation strength of the secondary control circuit.
8. Remove ALL shorting wire on Current Transformers and secondary block before placing unit back into service.
9. Remove jumper from contactor coil assembly points (A) to (B).

**WARNING**

FAILURE TO REMOVE ALL SHORTING WIRE FROM CURRENT TRANSFORMERS AND SECONDARY CONNECTIONS MAY CAUSE INJURIES AND EQUIPMENT DAMAGE.

6.7 MECHANISM CHECK

Make a careful visual inspection of the mechanism for any loose parts such as bolts, nuts, pins, rings, etc. Check for excessive wear or damage to the LV-VSR components. Operate the LV-VSR several times electrically to verify operation.

6.8 LUBRICATION

All parts that require lubrication have been lubricated during the assembly with molybdenum disulphide grease. Cutler-Hammer No. 53701QB. Over a period of time, this lubricant may be pushed out of the way or degrade. Proper lubrication at regular intervals is essential for maintaining the reliable performance of the mechanism. The LV-VSR should be re-lubricated once a year. The locations shown in Figure 6-2 should be lubricated with a drop of non-synthetic light machine oil. After lubrication, operate the LV-VSR several times manually and electrically.

6.9 PRIMARY CIRCUIT RESISTANCE CHECK

Since the main contacts are inside the vacuum chamber they remain clean and require no maintenance at any time.

The dc resistance of the primary circuit may be calculated by measuring the voltage drop across the circuit. To check the primary circuit resistance remove the LV-VSR from the switchgear, close the LV-VSR and pass at least 10A dc through one of the breaker’s poles. Measure the voltage drop across the primary contacts and calculate the resistance. Repeat for the remaining two poles.

6.10 MAGNET OPERATING RANGE

If the magnet chatters, look for mechanical interference that prevents the magnet itself may be misaligned. The magnet gap can be seen from the left and right sides with the help of a flashlight. A screwdriver inserted into one of the long slots can be used as a lever to put a corrective set into the mounting plate around the magnet. It should not be necessary to do this unless the contactor has been damaged and it can be seen that the armature does not fit against the magnet. A poor magnet to armature fit usually produces a high dropout voltage and/or chatter.

Mechanical interference can be produced by various incorrect adjustments. Two specific points to check are:

A. Armature travel incorrect, causing the contact springs to be compressed into a solid, non-resilient “tube” that stops the crossbar rigidly. Refer to Eaton’s Electrical Services and Systems for assistance.

B. The auxiliary contact mounting brackets are mis-adjusted, so that a contact plunger bottoms solidly before the magnet seals. When the contactor is fully sealed closed, there should still be a small amount of travel remaining for the plungers.

L63 Auxiliary Contact Adjustment

The normal .34 inch pretravel gap for the L63 auxiliary contact (normally-closed) is important. If the gap is too big, the “hold” winding of the operator coil will not be inserted as the contactor closes, and the pickup winding will burn out, because the pickup winding is only intermittently rated. If the gap is too small, the hold winding will be inserted too soon, reducing the force to “hold” before the contactor is closed, and producing an oscillation like a doorbell. In a particular contactor, the .34 gap may need slight adjustment to avoid these problems. The key is not the measurement, but the performance of the magnet.

The auxiliary contacts are not as critical. In the open position, their plungers may rest lightly against the operating arm, or may have a small clearance. However, neither of the auxiliary contact plungers should bottom solidly in the closed contactor position, as discussed under MAGNET OPERATING RANGE. If required, the auxiliaries can be adjusted by resetting their mounting brackets in their slotted holes. Adjust the L63 by loosening the two slotted hexagonal washer head screws that hold the L63 mounting bracket, repositioning and tightening. These bracket mounting screws are accessible from the top side of the contactor and are recognized by the slotted holes under their heads.
## Trouble Shooting Chart

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Inspection Area</th>
<th>Possible Defects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fails To Close</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blown Fuse(s)</td>
<td>• Fuses</td>
<td>• Unit experienced a overcurrent or short-circuit.</td>
</tr>
<tr>
<td></td>
<td>• Overload Relay</td>
<td>• Unit experienced an overcurrent and that exceeded OL Relay set point.</td>
</tr>
<tr>
<td></td>
<td>• Control Circuit</td>
<td>• Fuses blown (Control Power)</td>
</tr>
<tr>
<td></td>
<td>• Handle</td>
<td>• VSR will not operate if racking handle is not in the full down position.</td>
</tr>
<tr>
<td>Undesirably Closes</td>
<td>• Control Circuit</td>
<td>• Close Circuit (CS/C Shorted)</td>
</tr>
<tr>
<td><strong>Fails To Trip</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Control Circuit</td>
<td>• Fuses blown (Control Power)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Secondary Disconnects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• T-Relay</td>
</tr>
<tr>
<td>Undesirably Trips</td>
<td>• Control Circuit</td>
<td>• Trip Circuit (CS/T Shorted)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• OL Relay not set correctly</td>
</tr>
</tbody>
</table>
SECTION 7: REPLACEMENT OF COMPONENTS

7.1 GENERAL
In order to minimize production downtime, it is recommended that an adequate quantity of spare parts carried in stock. The quantity will vary from customer to customer, depending upon the service severity and continuity requirements. Each customer should develop his own level based on operating experience.

7.1.1 ORDERING INSTRUCTIONS
1. Always specify the LV-VSR rating information and general order number, from the nameplate.
2. Describe the item, give the style number, and specify the quantity required.
3. Specify the voltage for electrical components.
4. Specify the method of shipping desired.
5. Send all orders or correspondence to the nearest Eaton’s Electrical Services & Systems sales office.
6. Include negotiation number with order when applicable.